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National Eutrophication Survey, Corvallis, Oreg

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Apr 77

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NATIONAL EUTROPHICATION SURVEY

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REPORT
ON
MELVERN RESERVOIR
OSAGE COUNTY
KANSAS
EPA REGION VII
WORKING PAPER No. 518

WITH THE COOPERATION OF THE
KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT
AND THE
KANSAS NATIONAL GUARD
APRIL, 1977

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Kansas State Department of Health and Environment for professional involvement, to the Kansas National Guard for conducting the tributary sampling phase of the Survey, and to those Kansas wastewater treatment plant operators who voluntarily provided effluent samples and flow data.

The staff of the Kansas Division of Environmental Health provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

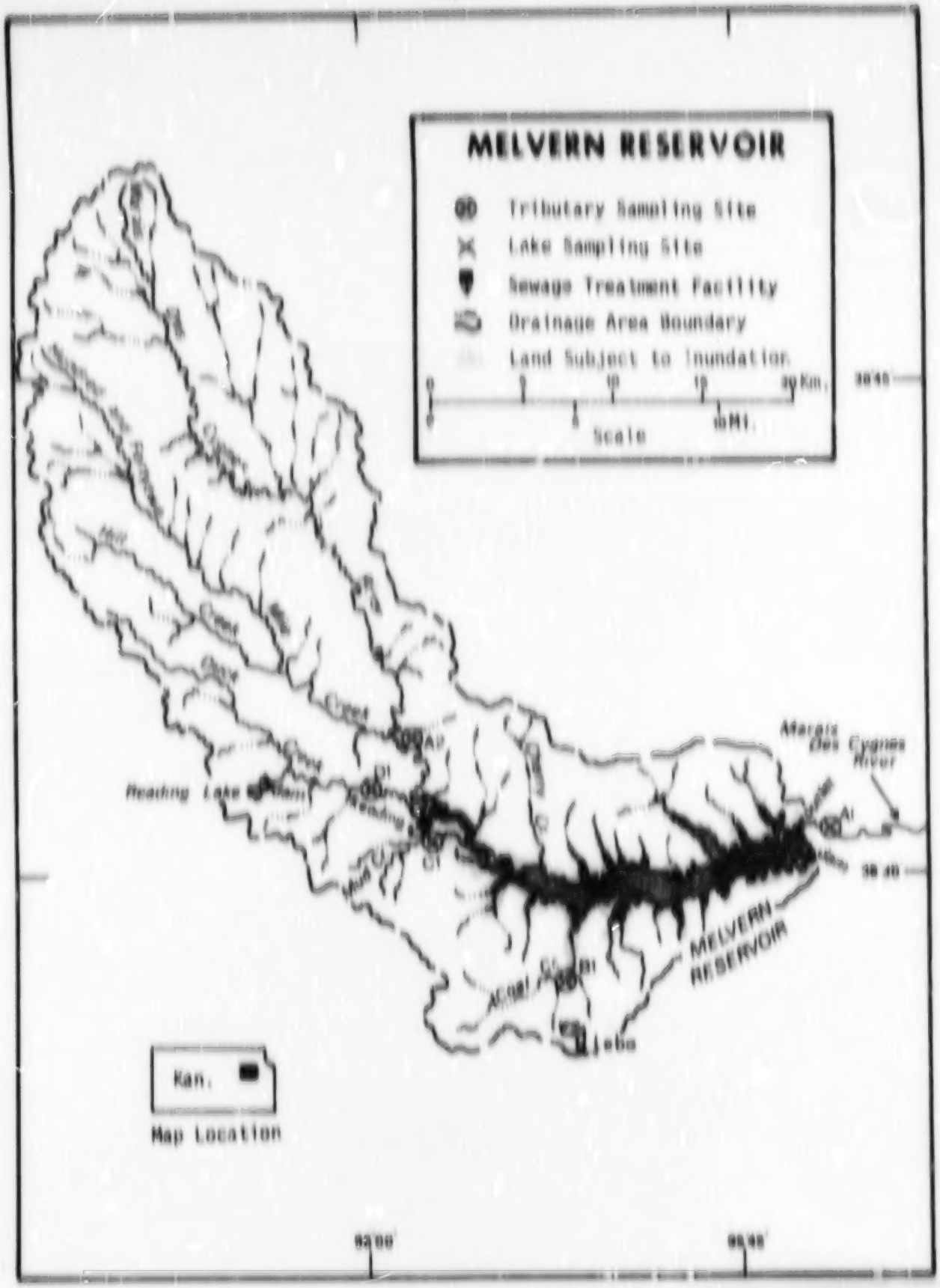
Major General Edward R. Fry, the Adjutant General of Kansas, and Project Officer Colonel Albin L. Lundquist, who directed the volunteer efforts of the Kansas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

STATE OF KANSAS

NAME	COUNTY
Cedar Bluff	Trego
Council Grove	Morris
Elk City	Montgomery
Fall River	Greenwood
John Redmond	Coffey, Lyon
Kanopolis	Ellsworth
Marion	Marion
Melvern	Osage
Milford	Clay, Geary
Norton	Norton
Perry	Jefferson
Pomona	Osage
Toronto	Greenwood, Woodson
Tuttle Creek	Marshall, Pottawatomie, Riley
Wilson	Russell


MELVERN RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Sewage Treatment Facility
Drainage Area Boundary
Land Subject to Inundation
0 5 10 15 20 Km.
0 5 10 Mi.
Scale
Reading Lake
Reading
Melvern
Arkansas Dos Cygnes River
MELVERN RESERVOIR
Lebo
Kan.
Map Location

MELVERN RESERVOIR

STORET NO. 2008

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate Melvern Reservoir is eutrophic. It ranked sixth in overall trophic quality when the 15 Kansas reservoirs sampled in 1974 were compared using a combination of six parameters*. Three of the reservoirs had less median total phosphorus and dissolved orthophosphorus, two had less and one had the same median inorganic nitrogen, 14 had less mean chlorophyll a, and two had greater mean Secchi disc transparency. Marked depressions of dissolved oxygen with depths occurred at two of the three sampling stations in June.

Survey limnologists observed surface concentrations of algae in June and October; however, phytoplankton were relatively sparse in the samples collected at those times (see page 6).

B. Rate-Limiting Nutrient:

The algal assay results indicate Melvern Reservoir was phosphorus limited at the time the sample was taken (04/12/74).

The reservoir data indicate phosphorus limitation all three sampling times.

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* See Appendix A.

c. Nutrient Controllability:

1. Point sources--The only known point source, the town of Reading, contributed 1.4% of the total phosphorus load reaching Malvern Reservoir during the sampling year.

The present phosphorus loading of 0.79 g/m²/yr is 1.7 times that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading (see page 12). Considering the relatively small point-source contribution, it does not seem likely that control of phosphorus at the Reading wastewater treatment plant would result in any significant improvement in the trophic condition of the reservoir.

2. Non-point sources--Non-point sources accounted for 98.6% of the total phosphorus load to the reservoir during the sampling year. The Marais Des Cygnes River contributed 50.5% of the total; Mud Creek, 2.1%; and the ungaged tributaries contributed an estimated 43.8%.

The phosphorus export rate of both the Marais Des Cygnes River and Mud Creek was 24 kg/km²/yr (see page 11). This rate was higher than the rates of three of the four tributaries of nearby Pomona Reservoir* (mean of 12 kg/km²/yr) but lower than the Switzler Creek rate (37 kg/km²/yr).

* Working Paper No. 522.

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS†

A. Morphometry††:

1. Surface area: 28.05 kilometers².
2. Mean depth: 6.0 meters.
3. Maximum depth: 16.2 meters.
4. Volume: 168,300 x 10^3 m^3.
5. Mean hydraulic retention time: 1.1 years (based on outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)*	Mean flow (m^3/sec)*
Marais Des Cygnes River	458.4	2.830
Mud Creek	19.4	0.120
Minor tributaries & immediate drainage -	403.2	3.230
Totals	881.0	6.180

2. Outlet -

Marais Des Cygnes River	909.1**	5.030

C. Precipitation***:

1. Year of sampling: 83.1 centimeters.
2. Mean annual: 95.1 centimeters.

† Table of metric conversions--Appendix B.
†† Stoltenberg, 1975.
* For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Nelvern Reservoir was sampled three times during the open-water season of 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the reservoir (see map, page v). During each visit, a single depth-integrated (4.6 m or near bottom to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the April visit, a single 18.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 19.2 meters at station 1, 14.3 meters at station 2, and 6.7 meters at station 3.

The sampling results are presented in full in Appendix B and are summarized in the following table.

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B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
04/12/74	1. Centric diatoms	18,106
	2. Melosira sp.	2,495
	3. Chroomonas sp.	927
	4. Cryptomonas sp.	530
	5. Ankistrodesmus sp.	221
	Other genera	485
	Total	22,764
06/25/74	1. Cryptomonas sp.	243
	2. Schroederia sp.	195
	3. Chroomonas sp.	141
	4. Stephanodiscus sp.	146
	5. Lepocinclis sp.	97
	Other genera	49
	Total	876
10/01/74	1. Melosira sp.	1,399
	2. Pediastrum sp.	392
	3. Centric diatoms	336
	4. Anabaena sp.	224
	5. Aphanizomenon sp.	112
	Other genera	223
	Total	2,686

B. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (mg/l)
04/12/74	1	58.6
	2	74.7
	3	60.7
06/25/74	1	0.8
	2	6.8
	3	5.9
10/01/74	1	14.8
	2	27.4
	3	24.5

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	<0.005	0.079	0.1
0.050 P	<0.055	0.079	2.0
0.050 P + 1.0 N	<0.055	1.079	10.8
1.0 N	<0.005	1.079	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Malvern Reservoir was low at the time the sample was taken (04/12/74). Increased growth occurred when only phosphorus was added, but no such response occurred with the addition of only nitrogen. These results indicate that Malvern

Reservoir was phosphorus limited at that time.

The reservoir data substantiate the assay findings. The mean inorganic nitrogen to orthophosphorus ratios were 78 to 1 in April, 26 to 1 in June, and 23 to 1 in October; i.e., phosphorus limitation is indicated all three times.

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Kansas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff months of May and June when two samples were collected at most of the sites. Sampling was begun in October, 1974, and was completed in September, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Kansas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a U.S. Geological Survey computer program for calculating stream loadings*. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the means of the nutrient loads, in kg/km^2/year, at stations A-2 and C-1 and multiplying the means by the ZZ area in km^2.

The operator of the Reading wastewater treatment plant provided monthly effluent samples but could not provide corresponding flow data. Therefore, nutrient loads were estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

* See Working Paper No. 175.

A. Waste Sources:

1. Known municipal* -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Reading	275	stab. pond	104.1	trib/Marais Des Cygnes River

2. Known industrial - None

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Marais Des Cygnes River	11,150	50.5
Mud Creek	460	2.1
b. Minor tributaries & immediate drainage (non-point load) -	9,675	43.8
c. Known municipal STP's -		
Reading	310	1.4
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation** -	490	2.2
Total	22,085	100.0

2. Outputs -

Reservoir outlet - Marais Des Cygnes River 8,465

3. Net annual P accumulation - 13,620 kg.

* Treatment plant questionnaire.
** See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Marais Des Cygnes River	251,560	49.9
Mud Creek	9,740	1.9
b. Minor tributaries & immediate drainage (non-point load) -	211,880	42.0
c. Known municipal STP's -		
Reading	935	0.2
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	30,285	6.0
Total	504,400	100.0

2. Outputs -

Reservoir outlet - Marais Des Cygnes River	355,240

3. Net annual N accumulation - 149,160 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Marais Des Cygnes River	24	949
Mud Creek	24	602

* See Working Paper No. 175.

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Coal Creek	0.155	2.395
Duck Creek	0.192	2.367

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m²/yr	0.79	0.49	18.0	5.3

Vollenweider phosphorus loadings (g/m²/yr) based on mean depth and mean hydraulic retention time of Malvern Reservoir:

"Dangerous" (eutrophic loading)	0.46
"Permissible" (oligotrophic loading)	0.23

V. LITERATURE REVIEWED

Stoltenberg, Gerald A., 1975. Personal communication (reservoir morphometry). KS Dept. of Health & Environment, Topeka.

Vollenweider, R. A., and P. J. Dillon, 1974. The application of the phosphorus loading concept to eutrophication research. Natl. Res. Council of Canada Publ. No. 13690, Canada Centre for Inland Waters, Burlington, Ontario.

VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN RAMONE

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG N	SIO2 MGM SEC	MGM CHLPA	15- MGM DT	[illegible] SECC SECHI P
2601	CEDAR BLUFF RESERVOIR	0.017	0.055	43,467	4.27	33,000	0.054
2602	COUNCIL GROVE	0.064	.033	45,000	9.700	30,400	0.029
2603	ELK CITY	0.030	0.590	46,400	3.222	24,000	0.060
2604	FALL RIVER RESERVOIR	0.053	0.470	48,467	7.60C	9,200	0.026
2605	JOHN REDMOND RESERVOIR	0.110	1.252	42,667	9.467	5,200	0.096
2606	KANOPOLIS RESERVOIR	0.056	0.040	47,000	16,000	10,200	0.001
2607	MARION RESERVOIR	0.052	0.430	48,467	12,400	9,000	0.050
2608	MELVERN RESERVOIR	0.024	0.205	49,000	30,400	24,400	0.007
2609	MILFORD RESERVOIR	0.074	0.720	46,000	26,800	20,000	0.026
2610	NORTON RESERVOIR	0.122	0.110	49,750	21,200	6,000	0.026
2611	PERRY RESERVOIR	0.055	0.470	48,57?	5.02+	33,400	0.007
2612	POMONA RESERVOIR	0.040	1.240	48,000	6,002	33,000	0.021
2613	TORONTO RESERVOIR	0.067	0.425	48,500	6,000	33,000	0.011
2614	TUTTLE CREEK RESERVOIR	0.062	0.470	-70,467	33,270	33,600	0.067
2615	WILSON RESERVOIR	0.020	0.205	46,000	6,067	33,400	0.004

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PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	SUB-MEDIAN SEC	MEDIAN CHLPHA	25-MEDIAN	MEDIAN SECCHI D	INCREASE
2801	CEDAR BLUFF RESERVOIR	100 (34)	100 (34)	100 (34)	40 (13)	57 (19)	65 (22)	53%
2802	COUNCIL GROVE	29 (10)	29 (10)	26 (9)	42 (14)	84 (29)	29 (10)	25%
2803	ELK CITY	86 (29)	58 (20)	7 (2)	100 (34)	7 (2)	100 (34)	9%
2804	FALL RIVER RESERVOIR	57 (19)	57 (19)	34 (11)	71 (24)	76 (26)	58 (20)	28%
2805	JOHN REDMOND RESERVOIR	24 (8)	8 (2)	8 (2)	58 (20)	40 (14)	7 (2)	3%
2806	KANOPOLIS RESERVOIR	43 (14)	43 (14)	29 (10)	21 (7)	71 (24)	84 (28)	27%
2807	MARION RESERVOIR	84 (28)	84 (28)	43 (14)	29 (10)	86 (29)	71 (24)	35%
2808	MELVERN RESERVOIR	79 (27)	82 (28)	86 (29)	8 (2)	8 (2)	76 (26)	26%
2809	MILFORD RESERVOIR	21 (7)	26 (9)	79 (27)	34 (11)	58 (20)	34 (11)	22%
2810	NORTON RESERVOIR	7 (2)	40 (13)	84 (28)	7 (2)	100 (34)	21 (7)	28%
2811	PERRY RESERVOIR	58 (20)	29 (10)	57 (19)	86 (29)	25 (8)	43 (14)	27%
2812	POMONA RESERVOIR	71 (24)	7 (2)	58 (20)	84 (28)	34 (11)	34 (11)	29%
2813	TORONTO RESERVOIR	34 (11)	71 (24)	21 (7)	79 (27)	34 (11)	57 (19)	38%
2814	TUTTLE CREEK RESERVOIR	8 (2)	29 (10)	71 (24)	34 (11)	34 (11)	8 (2)	13%
2815	WILSON RESERVOIR	43 (14)	40 (13)	43 (14)	57 (19)	25 (8)	84 (28)	45%

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107 x 10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

[illegible]

APPENDIX D

PHYSICAL and CHEMICAL DATA

| | | |

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APPENDIX E

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

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